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Variations in Preoperative Use of Bone Scan among Medicare Beneficiaries Undergoing Radical Cystectomy

Robert M. Turner II, M.D.¹, Jonathan G. Yabes, Ph.D.^{2,3}, Benjamin J. Davies, M.D.¹, Dwight E. Heron, M.D., M.B.A.⁴, and Bruce L. Jacobs, M.D., M.P.H.^{1,3}

¹Department of Urology, University of Pittsburgh Medical Center, Pittsburgh, PA, USA

²Division of Internal Medicine, Department of Medicine, University of Pittsburgh, Pittsburgh, PA, USA

³Center for Research on Health Care, Department of Medicine, University of Pittsburgh, Pittsburgh, PA, USA

⁴Department of Radiation Oncology, University of Pittsburgh Cancer Institute, Pittsburgh, PA, USA

Abstract

Objectives—To examine factors associated with the bone scan use in patients undergoing radical cystectomy and to assess trends in use over time.

Methods—Using Surveillance, Epidemiology, and End Results-Medicare data, we identified 5,573 patients who underwent radical cystectomy from 2004–2011. The primary outcome was completion of a bone scan within 6 months prior to surgery. Demographic, regional, and clinicopathologic predictors of bone scan use were examined using a mixed logit model with health service area as a random effect.

Results—Among radical cystectomy patients, 1754 (31%) completed a preoperative bone scan. Urologists ordered most of these studies (69%). The adjusted probability of a patient undergoing a bone scan decreased from 0.40 in 2004 to 0.29 in 2011 ($p = 0.01$). Compared with patients in the northeast region, those in the south, central, and west regions were less likely to have a bone scan ($p < 0.001$). Compared with those with stage T1, patients with higher stage disease were more likely to have a bone scan ($p < 0.001$). Amongst the highest volume surgeons, there was significant variation in the proportion of patients who completed preoperative bone scans ($p < 0.001$).

Conclusions—Despite a recent decline, bone scans are used frequently in the preoperative staging of bladder cancer. Although some clinical factors are associated with bone scan use, significant regional and provider variation suggest areas to improve standardization of practice.

Corresponding Author: Robert M. Turner II, M.D., 1350 Locust Street, Suite G100A Pittsburgh, PA, 15219 Ph: 412.232.5950 Fax: 412.232.6940, turnerrm@upmc.edu.

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Keywords

SEER Program; Medicare; Urinary Bladder Neoplasms; Neoplasm Staging; Radionuclide Imaging; Health Services Research

Introduction

Radical cystectomy is the gold standard treatment for patients with muscle-invasive bladder cancer and is indicated in some patients with non-muscle-invasive disease.¹ Although radical cystectomy can be curative, a modest proportion of patients will die from metastases present at the time of diagnosis.^{2–5} To minimize unnecessary surgery in these patients, current guidelines recommend preoperative imaging of the chest, abdomen, and pelvis, most commonly with a chest radiograph and computed tomography (CT) or magnetic resonance imaging (MRI) of the abdomen and pelvis.^{1, 6}

However, there remains controversy over whether bone scans should be used preoperatively. Guidelines recommend use of bone scan in the presence of clinical suspicion (i.e., elevated alkaline phosphatase) or symptoms of bone metastasis (i.e., bone pain).^{1, 6} The incidence of bone metastasis is reported to be as high as 27% in high-risk patients presenting with muscle-invasive disease.⁷ Thus, when one considers only those patients with the highest likelihood of bone metastasis (muscle invasion, history of bone pain, raised alkaline phosphatase), bone scan is thought to have value in guiding proper management and avoiding unnecessary surgery.⁶ Conversely, others argue that the likelihood of a true positive bone scan is as low as 2.8% in all-comers being considered for surgery.⁸ Furthermore, there are concerns about the poor specificity and positive predictive value of bone scan, which may lead to unnecessary downstream imaging and procedures.⁹ Regardless, the current use of bone scan in the preoperative setting in the United States is unknown.

For this reason, we conducted a population-based cohort study to better understand the current use of bone scan in the United States. We evaluated demographic, clinical, and pathologic factors associated with bone scan use and assessed the variation of use by providers. The goal of these efforts was to inform strategies to further standardize care in this patient population.

Materials and Methods

Study Population

Using Surveillance, Epidemiology, and End Results (SEER)-Medicare data, we identified patients who underwent radical cystectomy (International Classification of Diseases, Ninth Revision [ICD-9] codes 57.7, 57.71, 57.79, 68.8) for the treatment of bladder cancer between 2004 and 2011.¹⁰ All operations were performed in the United States. The date of surgery was identified using the Medicare Provider Analysis and Review (MEDPAR) files.¹¹ We included patients between the ages of 66 and 99 who were continuously enrolled in Medicare Parts A and B during the 12 months before and 1 month after cystectomy. We excluded patients participating in a health maintenance organization or Medicare Part C to ensure all health care was ascertained. We also excluded patients diagnosed at autopsy or

death and those with another diagnosis of a nonurothelial malignancy, including prostate cancer, prior to cystectomy. Those with a concomitant diagnosis of prostate cancer at the time of cystectomy were included in the analysis.

Outcomes

The primary outcome was completion of a bone scan within 6 months prior to radical cystectomy. Bone scan (including single-photon emission computed tomography [SPECT]) use was identified in the Medicare outpatient and carrier files by using Healthcare Common Procedure Coding System (HCPCS) codes 78300, 78305, 78306, 78315, and 78320.

Patient demographic and pathological information was obtained using the SEER Patient Entitlement and Diagnosis Summary File (PEDSF).¹⁰ As part of the demographic information, local census tract information (i.e., percentage of ZIP code population with at least a high school education, population of the county of residence, and the median household income within the ZIP code) was obtained. Geographic region (northeast, south, central, west) was categorized based on SEER region at the time of the bladder cancer diagnosis that most closely preceded surgery. Pathologic information included histology type and tumor grade and stage. Histology type was categorized based on the International Classification of Diseases for Oncology, Third Edition (ICD-O-3) histology codes.¹² Local tumor stage was based on the American Joint Committee on Cancer, 6th ed., T stage data derived through the SEER Collaborative Stage algorithm.^{13,14}

Preoperative assessment of an alkaline phosphatase level, receipt of neoadjuvant chemotherapy, and type of urinary diversion were evaluated using Medicare outpatient and carrier files (supplemental table).¹⁰ Patient comorbidity was determined by evaluating diagnoses from Medicare claims for the 12 months prior to cystectomy.¹⁵ The surgeon and bone scan ordering provider were identified using Medicare outpatient and carrier files. The specialty of the ordering provider was identified using a two-step process. First, we identified the National Provider Identifier (NPI) and/or Unique Physician Identification Number (UPIN) associated with the bone scan claim in the carrier file. Second, we used the carrier files to identify the Health Care Financing Administration (HCFA) Specialty code associated with each provider.

Statistical Analysis

The study population was dichotomized by bone scan use, and demographic, socioeconomic, and pathologic characteristics of the study population were compared between groups using Chi square tests.

Covariates were analyzed using a mixed logit model with health service area as a random effect to account for patients nested within health service areas. Health service areas are defined as “one or more counties that are relatively self-contained with respect to the provision of routine hospital care” and are used by the National Center for Health Statistics for geographic patterns of care analyses.¹⁶ The health service area for each patient was identified in the SEER PEDSF File. Covariates included age, sex, race, comorbidity, marital status, education level and median income in ZIP code of residence, county population, region, grade, stage, measurement of an alkaline phosphatase level, and year of surgery.

Variables used in the adjusted model included age, race, comorbidity, and those that had $P < 0.1$ in the univariate analyses.

A cohort of the highest volume surgeons, defined as those who performed 10 or more cystectomies over the study period, was identified. The proportion of each surgeon's patients who underwent preoperative bone scan was assessed. The relationship between the number of cystectomies performed by each surgeon and the use of bone scan was evaluated using Spearman rank correlation. Furthermore, a multivariable mixed logit model, with surgeon as a random effect, was used to assess the variance in the proportion of patients undergoing bone scan explained at the surgeon level. Variables used in the adjusted model included geographic region, receipt of neoadjuvant chemotherapy, local tumor stage, and year of surgery. A likelihood ratio test was conducted comparing models with and without the surgeon random effect.

Statistical analyses were performed using R (version 13.2)¹⁷ using the packages dplyr¹⁸ for data manipulation, compareGroups¹⁹ for descriptive tables, and ggplot2²⁰ for graphics. Statistical significance was defined as $P < 0.05$. The University of Pittsburgh institutional review board approved the study protocol (PRO14020541).

Results

The demographic, clinical, and pathological information for the study groups are summarized in Table 1. Among 5573 patients who underwent radical cystectomy during the study period, 1754 (31%) completed a preoperative bone scan. There were no differences in age, race, baseline comorbidity, and ZIP code median household income between those patients who did and did not undergo a bone scan. Among 274 patients with stage T1 who did not have an alkaline phosphatase assessment, 60 (22%) completed a preoperative bone scan. Of the 1754 preoperative bone scans, 1216 (69%) were ordered by urologists (Supplemental Figure).

The univariate and multivariable analyses examining predictors of bone scan use are shown in Table 2. After adjusting for covariates, geographic region ($p < 0.001$), receipt of neoadjuvant chemotherapy ($p < 0.001$), local tumor stage ($p < 0.001$), and year of surgery ($p = 0.01$) were independently associated with bone scan use. Compared with patients in the northeast region, patients in the south (adjusted odds ratio [aOR] 0.37 95% confidence interval [CI] 0.24–0.58), central (aOR 0.29 95% CI 0.18–0.49), and west (aOR 0.58 95% CI 0.38–0.89) were less likely to have a bone scan. Those patients who received neoadjuvant chemotherapy were more likely undergo bone scan than those who did not (aOR 1.38 95% CI 1.14–1.67). Compared with those with stage T1, patients with T2 (aOR 1.80 95% CI 1.51–2.15), T3 (aOR 2.12 95% CI 1.75–2.55), and T4 (aOR 2.22 95% CI 1.78–2.77) disease were more likely to have a bone scan. The adjusted probability of undergoing a bone scan decreased from 0.40 in 2004 to 0.29 in 2011 ($p = 0.01$, Figure 1).

A total of 102 surgeons performed 10 or more radical cystectomies over the study period. The proportion of each provider's patients who completed a preoperative bone scan is shown in Figure 2. There was no evidence of an association between surgeon volume and bone scan

use ($r = 0.05$, $p = 0.62$). After adjusting for geographic region, receipt of neoadjuvant chemotherapy, local tumor stage, and year of surgery, there was significant variability in bone scan use at the provider level ($p < 0.001$).

Discussion

Although bone scan use declined over the study period, preoperative staging with bone scan prior to radical cystectomy remains common practice. In this large population-based study, approximately 31% of patients who underwent surgery completed a preoperative bone scan—the majority of which were ordered by urologists. Demographic (geographic variation), clinical (receipt of neoadjuvant chemotherapy), and pathologic (advanced local tumor stage) factors were also independently associated with bone scan use. After adjusting for these factors, there was significant surgeon-level variation in bone scan use.

Routine staging with bone scan prior to radical cystectomy has generally been discouraged in the absence of clinical suspicion or symptoms of bone metastases.^{1,6} The rationale for current guidelines is based on a low frequency of positive bone scans—as low as 2.7% in a historical cohort⁸—and the poor ability to identify patients who will not be cured by radical surgery.²¹

However, the proportion of patients with a positive bone scan is highest when applied to those with muscle-invasive disease, a history of bone pain, and/or an elevated alkaline phosphatase level.⁹ Thus, there is some enthusiasm for using bone scans in these high-risk patients to identify bone metastasis not detected by preoperative computed tomography.^{9,22} Patients in our study with more advanced tumor stage were more likely to have a bone scan. To the contrary, however, nearly 20% of patients with stage T1 disease underwent a bone scan, and there was no association between measurement of alkaline phosphatase and bone scan use. In fact, 18% of the patients in our cohort did not have an alkaline phosphatase level assessed preoperatively. While one might expect that those patients who underwent alkaline phosphatase assessment were more likely to have had a bone scan, we found no such relationship.

Furthermore, patients who received neoadjuvant chemotherapy were more likely to complete a preoperative bone scan, perhaps on account of the multidisciplinary approach to these patients. Despite evidence that neoadjuvant cisplatin-based chemotherapy improves overall survival in muscle-invasive bladder cancer, utilization remains low, attributable in part to patient/physician choice and patient comorbidities.^{23–25} This poor adoption is highlighted in our cohort, in which only 15% of patients with muscle-invasive disease received neoadjuvant chemotherapy.

In addition to these clinical findings, there were nonclinical factors associated with the use of bone scan, including the region in which a patient lived and the provider who performed their operation. Specifically, patients in the northeast United States were more than twice as likely to undergo preoperative bone scan than other areas of the country. This relationship persisted after adjusting for other clinicopathologic and demographic predictors of use. Others have demonstrated increased healthcare expenditure and variation in practice patterns

in the northeastern United States.^{26–32} Regional variation in bladder cancer staging, including the use of bone scan, has also been described in Ontario, Canada.²⁷ In a large population-based cohort study of 2,802 patients with muscle-invasive bladder cancer who underwent radical cystectomy in the Ontario Cancer Registry, there was substantial regional variation in use of bone scan (27–40%) that persisted on adjusted analyses. The authors concluded that evidence of regional practice variability represents opportunities for improvement regarding uniformity of practice in their province.

Similarly, there was significant variation in bone scan use at the provider level. Among the highest volume surgeons, as many as 90% to as few as 0% of patients underwent preoperative bone scan, even after adjusting for multiple patient, demographic, and clinical factors that could influence use. This suggests that a large proportion of surgeons are dogmatic in their approach to preoperative bone scans and do not alter their ordering pattern based on the likelihood of detecting metastatic disease. This is further highlighted by the finding that 20% of patients in the study without an apparent indication for bone scan – those with stage T1 disease and no alkaline phosphatase assessment – completed a bone scan prior to surgery. As our health system places more emphasis on value-based care, this potentially identifies a target for quality improvement and cost reductions through mechanisms that aim to reduce unnecessary testing and healthcare costs. Two examples include the Choosing Wisely campaign, an initiative of the American Board of Internal Medicine Foundation that promotes patient-centered care by informing patients and physicians about overutilization of medical resources, and bundled payment models, which reimburse health care providers on the basis of expected costs for clinically-defined episodes of care.

These findings should be considered in the context of several limitations. First, we used Medicare hospitalization claims, thus potentially limiting the generalizability of our findings; however, the majority of patients with bladder cancer are in the seventh decade of life or older and have Medicare coverage. Second, due to limitations in the use of claims data, the analysis could not include details about the indications for the bone scan (i.e., symptoms, elevated alkaline phosphatase) in the population; however, we were able to consider those patients who did and did not undergo alkaline phosphatase assessment. Furthermore, it is unlikely that the degree of regional and provider variability identified in this study can be explained by these factors alone. Third, the analysis relied on the generic SEER grade variable that is required for all cancer sites. Lastly, like any retrospective observational study, this is limited by unmeasured confounding variables, including availability or proximity of nuclear medicine facilities, patient travel distance, and use of alternative imaging modalities, that could not be corrected for in our adjusting analyses; however, we adjusted for several measurable clinical and nonclinical factors and accounted for patients nested within health service areas.

Conclusions

Although bone scan use has decreased over time, these studies are still obtained in nearly a third of patients prior to radical cystectomy. Furthermore, there is considerable variation of use in routine clinical practice. Although some clinical factors are associated with bone scan

use, there was also significant regional and provider variation. While the reasons for this variability are unclear, these findings identify a need for further investigation to identify ways to standardize the preoperative staging of patients with bladder cancer.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Figure 1. Adjusted probability of preoperative bone scan use over time

The adjusted probability of completing a bone scan decreased from 0.40 in 2004 to 0.29 in 2011 ($p = 0.01$, test for trend). Estimates are adjusted for age, sex, race, comorbidity, marital status, county population, median income in ZIP code of residence, geographic region, measurement of an alkaline phosphatase level, receipt of neoadjuvant chemotherapy, grade, and stage.

Figure 2. Variability of bone scan use among highest volume surgeons
Percentage of patients who underwent preoperative bone scan among the 102 highest-volume surgeons (10 cystectomies). Surgeon IDs are sorted from maximum to minimum percentage of patients with bone scan. The maximum percentage is 96%.

Table 1

Demographic, socioeconomic, and pathological characteristics of the study population

Characteristics	No Bone Scan (N = 3819)	Bone Scan (N = 1754)	P value*
Age at cystectomy (%)			0.13
66–69	723 (19)	291 (17)	
70–74	1049 (28)	513 (29)	
75–79	1028 (27)	492 (28)	
80 or more	1019 (27)	458 (26)	
Sex (%)			0.07
Male	2858 (77)	1271 (73)	
Female	961 (25)	483 (28)	
Race (%)			0.18
White	3391 (89)	1534(88)	
Black	151 (4)	66 (4)	
Hispanic	148 (4)	75 (4)	
Other	129 (3)	79 (5)	
Comorbidity (%)			0.26
0	1663 (44)	718 (41)	
1	1053 (28)	520 (30)	
2	591 (16)	281 (16)	
3 or more	507 (13)	235 (13)	
Marital status (%)			0.02
Married	2547 (67)	1134 (65)	
Not married	1115 (29)	567 (32)	
Unknown	157 (4)	53 (3)	
Education level (%)**			0.90
Low (<75% with high school education)	418 (11)	195 (11)	
High (>75% with high school education)	3321 (89)	1525 (89)	
County of residence population (%)			<0.001
1,000,000 or more	2033 (53)	1029 (59)	
250,000–999,999	680 (18)	301 (17)	
Less than 250,000	1106 (29)	424 (24)	
Median household income (%)**			0.01
\$50,000 or less	1392 (37)	563 (33)	
\$50,001–\$70,000	1152 (31)	564 (33)	
More than \$70,000	1191 (32)	593 (35)	
U.S. geographic region (%)		<0.001	
Northeast	746 (20)	536 (31)	
South	979 (26)	311 (18)	

Characteristics	No Bone Scan (N = 3819)	Bone Scan (N = 1754)	P value*
Central	610 (16)	214 (12)	
West	1484 (39)	693 (40)	
Preoperative alkaline phosphatase level (%)		0.09	
No	701 (18)	288 (16)	
Yes	3118 (82)	1466 (84)	
Neoadjuvant chemotherapy (%)		<0.001	
No	3334 (87)	1455 (83)	
Yes	485 (13)	299 (17)	
Year of cystectomy (%)		0.004	
2004	429 (11)	242 (14)	
2005	509 (13)	255 (15)	
2006	477 (13)	244 (14)	
2007	479 (13)	236 (14)	
2008	540 (14)	220 (13)	
2009	472 (12)	189 (11)	
2010	448 (12)	193 (11)	
2011	465 (12)	175 (10)	
Type of Urinary Diversion (%)		0.58	
Conduit	2734 (72)	1278 (73)	
Continent diversion	603 (16)	269 (15)	
Other/Unknown	482 (13)	207 (12)	
Histology (%)		0.19	
Urothelial carcinoma	3533 (93)	1609 (92)	
Squamous cell carcinoma	101 (3)	62 (4)	
Other	185 (5)	83 (5)	
Grade (%)		<0.001	
Well/moderately differentiated	404 (11)	132 (8)	
Poorly/undifferentiated	3145 (82)	1524 (87)	
Unknown	270 (7)	98 (6)	
T stage (%)		<0.001	
T1 or less	1101 (33)	304 (19)	
T2	1128 (34)	584 (37)	
T3	741 (22)	438 (28)	
T4	391 (12)	248 (16)	

Abbreviations: SD, standard deviation; IQR, interquartile range. Percentages might not sum to 100 because of rounding.

* P values determined using Chi-square tests.

** Education level and median household income of the ZIP code of residence

Table 2

Unadjusted and adjusted estimated effects of each predictor on the use of preoperative bone scan

Predictor	Univariable analysis		Multivariable analysis	
	Odds Ratio (95% CI)	<i>P</i> value **	Adjusted Odds Ratio (95% CI)	<i>P</i> value
<i>Age at cystectomy</i>		0.13		0.09
66–69	reference		reference	
70–74	1.21 (1.02–1.44)		1.24 (1.02–1.50)	
75–79	1.19 (1.00–1.41)		1.15 (0.95–1.41)	
80 or more	1.12 (0.94–1.33)		1.03 (0.84–1.26)	
<i>Sex</i>		0.07		0.52
Male	reference		reference	
Female	1.13 (0.99–1.28)		1.05 (0.90–1.23)	
<i>Race</i>		0.18		0.19
White	reference		reference	
Black	0.97 (0.72–1.29)		0.83 (0.58–1.17)	
Hispanic	1.12 (0.84–1.49)		1.24 (0.90–1.72)	
Other	1.35 (1.01–1.80)		1.26 (0.90–1.78)	
<i>Comorbidity</i>		0.26		0.32
0	reference		reference	
1	1.14 (1.00–1.31)		1.16 (0.99–1.35)	
2	1.10 (0.93–1.30)		1.10 (0.90–1.33)	
3 or more	1.07 (0.90–1.28)		1.04 (0.85–1.28)	
<i>Marital status</i>		0.02		0.12
Married	reference		reference	
Not married	1.14 (1.00–1.31)		1.10 (0.95–1.28)	
Unknown	0.76 (0.55–1.04)		0.77 (0.53–1.11)	
<i>County of residence population</i>		<0.001		0.43
1,000,000 or more	reference		reference	
250,000–999,999	0.87 (0.75–1.02)		0.92 (0.68–1.26)	
Less than 250,000	0.76 (0.66–0.87)		1.11 (0.82–1.49)	
<i>Median household income ***</i>		0.01		0.36
Less than \$50,000	reference		reference	
\$50,001–\$70,000	1.21 (1.05–1.39)		0.98 (0.82–1.18)	
More than \$70,000	1.23 (1.07–1.41)		0.88 (0.72–1.08)	
<i>U.S. geographic region</i>		<0.001		<0.001
Northeast	reference		reference	
South	0.44 (0.37–0.52)		0.37 (0.24–0.58)	
Central	0.49 (0.40–0.59)		0.29 (0.18–0.49)	
West	0.65 (0.56–0.75)		0.58 (0.38–0.89)	

Predictor	Univariable analysis		Multivariable analysis	
	Odds Ratio (95% CI)	<i>P</i> value **	Adjusted Odds Ratio (95% CI)	<i>P</i> value
Alkaline phosphatase		0.09		0.77
No	reference		reference	
Yes	1.14 (0.99–1.33)		1.03 (0.86–1.22)	
Year of cystectomy		0.004		0.01
2004	reference		reference	
2005	0.89 (0.71–1.10)		0.90 (0.69–1.18)	
2006	0.91 (0.73–1.13)		0.85 (0.65–1.11)	
2007	0.87 (0.70–1.09)		0.84 (0.64–1.10)	
2008	0.72 (0.58–0.90)		0.68 (0.52–0.90)	
2009	0.71 (0.56–0.89)		0.68 (0.51–0.90)	
2010	0.76 (0.61–0.96)		0.70 (0.53–0.93)	
2011	0.67 (0.53–0.84)		0.63 (0.47–0.83)	
Neoadjuvant chemotherapy		<0.001		<0.001
No	reference		reference	
Yes	1.41 (1.21–1.65)		1.38 (1.14–1.67)	
Grade		<0.001		0.44
Well/moderately differentiated	reference		reference	
Poorly/undifferentiated	1.48 (1.21–1.83)		1.19 (0.91–1.54)	
Unknown	1.11 (0.82–1.50)		1.18 (0.81–1.73)	
T stage		<0.001		<0.001
T1 or less	reference		reference	
T2	1.87 (1.60–2.20)		1.80 (1.51–2.15)	
T3	2.14 (1.80–2.55)		2.12 (1.75–2.55)	
T4	2.30 (1.87–2.82)		2.22 (1.78–2.77)	

Abbreviations: CI, confidence interval

* Multivariable analysis incorporated a mixed logit model with health service area as a random effect to account for patients nested within health service areas. Estimates are adjusted for age, sex, race, comorbidity, marital status, county population, ZIP code median household income, geographic region, measurement of an alkaline phosphatase level, year of cystectomy, receipt of neoadjuvant chemotherapy, grade, and stage.

** Overall *P* values determined using partial likelihood-ratio tests

*** Median household income of the ZIP code of residence